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Assistant Commissioner for Patents
Box Patent Application
Washington, D.C. 20231



UTILITY PATENT APPLICATION TRANSMITTAL

Sir:

Transmitted herewith for filing is the patent application of:

First Named Applicant (or Application Identifier):

(First)
Katsumi SAMESHIMA

Title of Application: **FERROELECTRIC MEMORY AND METHOD FOR MANUFACTURING SAME**

1. Type of Application (37 C.F.R. 1.53(b))

This application is a(n):

☒ Original (nonprovisional) application.

☐ Continuing application:

☐ Divisional ☐ Continuation ☐ Continuation-in-Part (CIP)
of Serial No. 08/, filed on _____.

CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this New Application Transmittal and the documents referred to as enclosed herein are being deposited with the United States Postal Service on this date, **November 30, 1999**, in an envelope as "Express Mail, to Addressee" Mailing Label Number **EL457630818US**, addressed to the Commissioner of Patents and Trademarks, Washington, D.C. 20231.

Susan L. Toledano
Name of person mailing paper


Signature of person mailing paper

2. Enclosed Papers Required to Obtain Application Filing Date under 37 CFR 1.53(b)

<u>11</u>	Pages of specification		
<u>2</u>	Pages of claims		
<u>1</u>	Pages of Abstract		
<u>8</u>	Sheets of drawings	<input checked="" type="checkbox"/> Formal	<input type="checkbox"/> Informal

3. Oath or Declaration

- ☐ Newly executed Oath or Declaration (original or copy) is enclosed.
- ☐ Copy of Oath or Declaration from prior application 0 / (37 C.F.R. 1.63(d)).
- ☐ The entire disclosure of the prior application, from which a copy of the oath or Declaration is supplied, is considered as being a part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
- ☐ With Power of Attorney ☐ Without Power of Attorney
- ☒ Not enclosed.

4. Additional Papers Enclosed

- ☒ Return Receipt Postcard (specifically itemized) (M.P.E.P. § 503).
- ☐ Preliminary Amendment.
- ☐ Information Disclosure Statement (37 CFR 1.98).
- ☐ Form PTO-1449 ☐ Copies of IDS Citations
- ☐ Nucleotide and/or Amino Acid Sequence Listing computer-readable copy, paper copy, and statement verifying identity of computer-readable and paper copies.
- ☐ Certified Copy of Priority Document(s)
- ☐ Verified translation of non-English language application (37 C.F.R. 1.52(d)).
- ☐ Other: _____.

5. Assignment

- ☐ Newly Executed assignment with Recordation Cover Sheet (Form PTO-1595).
- ☐ Copy of Assignment from prior application No. 08/.
- ☒ Not enclosed.

6. Fee Calculation (37 CFR 1.16)

Regular Application (37 CFR 1.16(a))

Basic Fee **\$760.00**

FEES FOR CLAIMS AS FILED

Number filed

Number extra

Rate

Total Claims

(37 CFR 1.16(c))

- 20 = × \$ 18.00 = \$

Independent Claims

(37 CFR 1.16(b))

- 3 = × \$ 78.00 = \$

Multiple Dependent Claims

(37 CFR 1.16(d))

+ \$260.00 = \$

Fee Calculation for Extra Claims \$_____

☐ Amendment canceling extra claims enclosed.

☐ Amendment deleting multiple-dependencies enclosed.

Total Filing Fee Calculation \$_____,

7. Small Entity Statement

☐ Verified Statement that this is a filing by a small entity under 37 CFR 1.9 and 1.27:

☐ is enclosed. ☐ will follow.

☐ Status as a small entity was claimed in prior application **08/____**, from which benefit is being claimed for this application under:

☐ 35 U.S.C. 119(e),

☐ 35 U.S.C. 120,

☐ 35 U.S.C. 121,

☐ 35 U.S.C. 365(c),

and which status as a small entity is still proper and desired.

☐ A copy of the verified statement in the prior application is enclosed.

Filing Fee Calculation (50% of Filing Fee calculated in Item 6 above) \$_____

8. Fee Payment

☒ Not enclosed. No filing fee is to be paid at this time.

☐ Enclosed:

☐ Basic filing fee (Item 6 or 7 above) \$ _____

☐ Fee for recording Assignment
(\$40.00 (37 CFR 1.21(h))) \$ _____

☐ Processing and retention fee
(\$130.00 (37 CFR 1.53(d) and 1.21(l))) \$ _____

Total fees enclosed \$ _____.

9. Method of Payment of Fees

☐ Check in the amount of \$ _____.

☐ Charge Deposit Account No. 08-2461 in the amount of \$ _____.
A duplicate of this transmittal is enclosed.

10. Authorization to Charge Additional Fees

☐ The Commissioner is hereby authorized to charge the following additional fees by this paper and during the entire pendency of this application to Deposit Account No. 08-2461:

☐ 37 CFR 1.16(a), (f), or (g) (filing fees)

☐ 37 CFR 1.16(b), (c), and (d) (presentation of extra claims)

☐ 37 CFR 1.16(e) (surcharge for filing the basic fee and/or declaration at a date later than the filing date of the application)

☐ 37 CFR 1.17 (application processing fees)

A duplicate of this transmittal is enclosed.

11. Instructions as to Overpayment

☐ Credit Deposit Account 08-2461.

☐ Refund.

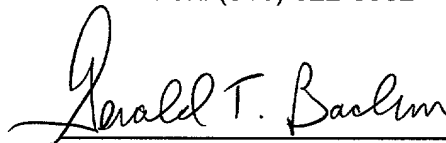
12. Correspondence Address

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GTB:slt

TITLE OF THE INVENTION

Ferroelectric Memory and Method for Manufacturing Same

BACKGROUND OF THE INVENTION

5 Field of the invention

This invention relates generally to a ferroelectric memory and method for manufacturing same and, more particularly, to a ferroelectric memory with a structure formed, on an insulation film, with a lower electrode, a ferroelectric and an upper electrode in this order, and a method for manufacturing such a ferroelectric memory.

10 Description of the prior art

The conventional ferroelectric memory 1 of this kind, shown in Figure 13, includes a not-shown semiconductor substrate and a first insulation film 2 formed thereon. On the first insulation film 2, a lower electrode 3, a ferroelectric film 4 and an upper electrode 5 are formed in this order. Further, a second insulation film 6 is formed in a manner covering these films. To fabricate a ferroelectric memory 1, a conductive film 3a is formed of platinum (Pt) or the like by sputtering over the first insulation film 2 formed on the semiconductor substrate, as shown in Figure 14(A). Then, a ferroelectric film 4a is formed of lead zirconate titanate (PZT) or the like on the conductive film 3a by a sol-gel process. A conductive film 5a is further formed by sputtering platinum (Pt) or the like over the ferroelectric film 4a. Then, as shown in Figure 14(B) dry etching is conducted sequentially on the conductive film 5a, the ferroelectric film 4a and the conductive film 3a, thereby providing an upper electrode 5, a ferroelectric film 4 and a lower electrode 3. Thereafter, an insulation film 6 (Figure 13) is formed in a manner covering these films by a CVD process.

25 In the prior art, however, a conductive film 5a, a ferroelectric film 4a and a

conductive film 3a are formed to a thickness to provide an upper electrode 5, a ferroelectric film 4 and a lower electrode 3, so that dry etching is then conducted throughout a total film thickness in order to remove unwanted portions of these films, Thus, the prior art has required a much etch amount and hence a long etch time. This results in long-time exposure of the ferroelectric film 4 to the plasma atmosphere during a dry etch process. The plasma however has effects upon the ferroelectric 4 to lower its switching charge amount (Q_{sw}). Thus, there has been a fear of causing such problem as worsening the symmetry in hysteresis and deteriorating the characteristics of coerciveness and fatigue.

SUMMARY OF THE INVENTION

It is therefore a primary object of the present invention to provide a ferroelectric memory having a ferroelectric characteristic that is free from deterioration, and a method for manufacturing same.

A ferroelectric memory according to the present invention, comprises: an insulation film; a hollow formed in a top surface of the insulation film; a lower electrode formed in the hollow; a ferroelectric formed on the lower electrode; and an upper electrode formed on the ferroelectric.

A manufacturing method according to the invention is a method for manufacturing a ferroelectric memory having a lower electrode, ferroelectric and upper electrode formed on an insulation film, characterized in that a hollow is formed in a surface of the insulation film and then a lower electrode is formed in the hollow by a process including an application process.

A hollow is formed in a top surface of an insulation film, and a lower electrode is formed in the hollow by a process including a spin coating method (e.g. sol-gel method).

In a spin-application process, a precursor solution is dripped on the surface of the insulation film and splashed away by a centrifugal force. Consequently, the conductive film being formed has a thickness increased in a hollow portion that the precursor solution is ready to collect, i.e. a portion to be formed into a lower electrode, and

5 decreased in other portion than the hollow. Accordingly, when etching the conductive film to form a lower electrode, it is satisfactory to etch only the portion other than the hollow, i.e. the thickness decreased portion of the conductive film, enabling etching in a brief time. However, where leaving the thinned portion of the conductive film for an interconnection, no etching is required. Also, if a first electrode portion is formed in a

10 corner of the hollow by a process including a spin coating method and further a second electrode portion is formed thereon by a process including a spin coating method, a resulting lower electrode is reduced in amount of a depression caused in a top surface center. Meanwhile, if a first electrode portion is formed at a hollow corner by a process including a spin coating method and further a second electrode portion is formed thereon

15 by sputtering, a resulting lower electrode is reduced in variation of crystalline orientation thereof. If a film is formed in a predetermined depth position with respect to a top surface of the insulation film to form a hollow in the insulation film by using this film as an etch stop, the hollow will have a flat bottom surface at the predetermined depth position.

Further, the film blocks the water content of the insulation film from reaching the

20 ferroelectric through the lower electrode. Furthermore, if the lower electrode in the hollow and the insulation film at their top surfaces are planarized flush with each other, there is no necessity to etch the conductive film at portions other than the hollow in the later process. If a thin film is formed on a planarized lower electrode by using a same material as the lower electrode, eliminated is surface roughening caused on the lower

25 electrode upon planarization.

According to the invention, it is possible to shorten a time for which the dielectric is exposed to a plasma atmosphere during a dry etch process. Thus, the ferroelectric can be prevented from being deteriorated in characteristics by a plasma effect.

Also, the ferroelectric can be stabilized in crystallinity and orientation by forming
5 a first electrode portion at a hollow corner and a second electrode portion thereon to provide a lower electrode or by forming a thin film on a planarized lower electrode.

Further, if a film is formed in the insulation film at a predetermined depth position with respect to a top surface thereof to form a hollow by utilizing the film as an etch stop, the hollow can be made flat in its bottom surface in the predetermined depth, making
10 possible to stably form a lower electrode. Also, this film serves to block the moisture content of the insulation film from reaching the ferroelectric, thus preventing the ferroelectric from being deteriorated in characteristics.

The above described objects and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description
15 of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an illustrative view showing one embodiment of the present invention;

Figure 2 is an illustrative view showing a method for manufacturing the Figure 1
20 embodiment;

Figure 3 is an illustrative view showing another embodiment of the present invention;

Figure 4 is a illustrative view showing a method for manufacturing the Figure 3 embodiment;

25 Figure 5 is an illustrative view showing a modification to the Figure 3

embodiment;

Figure 6 is an illustrative view showing another embodiment of the present invention;

Figure 7 is an illustrative view showing a state that a film for providing a
5 ferroelectric is formed over a planarized first conductive film and first insulation film;

Figure 8 is an illustrative view showing a state that a film for eliminating surface roughness is formed over a surface of the planarized first conductive film;

Figure 9 is an illustrative view showing a state that a film is formed in a first insulation film at a predetermined depth position thereof;

10 Figure 10 is an illustrative view showing a state that a first electrode portion is formed at a corner of a hole;

Figure 11 is an illustrative view showing a state of forming by sputtering a first conductive film forming second electrode portion on the first electrode portion;

15 Figure 12 is an illustrative view showing a state that a first electrode portion is formed on an entire bottom surface of a hole;

Figure 13 is an illustrative view showing a conventional ferroelectric memory; and

Figure 14 is an illustrative view showing a method for manufacturing a conventional ferroelectric memory.

20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 1, there is depicted a ferroelectric memory 10 of this embodiment which includes a first insulation film 12 formed on a not-shown silicon (Si) substrate. The first insulation film 12 has a hollow 14 formed in its top surface to have a lower electrode 16 inside the hollow 14. A ferroelectric 18 and an upper electrode 20 are
25 formed on the lower electrode 16 in this order. Further, a second insulation film 22 is

formed covering these elements.

A method for manufacturing a ferroelectric memory 10 will now be explained concretely with reference to Figure 2 and Figure 3. First, a not-shown silicon (Si) substrate is prepared, to form thereon by a CVD technique a first insulation film 12 of silicate glass containing phosphorus (PSG), silicate glass containing boron/phosphorus (BPSG) or the like. Subsequently, as shown in Figure 2(A) the first insulation film 12 is masked by a patterned resist 24 to form a hollow 14 by an RIE (reactive ion etching) technique as anisotropic dry etching. Then, as shown in Figure 2(B) a first conductive film 26 as a gel dry film is formed by a sol-gel technique on a surface of the first insulation film 12 including an inside of the hollow 14. That is, an Ir precursor solution is formed by subjecting a metal alkoxide solution containing irridium (Ir) as an ingredient element to hydrolysis/polycondensation. This solution is applied onto a surface of the first insulation film 12 by a spin coating technique, and then dried into a gel dry film. In an application process using a spin coating technique, the precursor solution dripped on the surface of the first insulation film is splashed away due to a centrifugal force. However, the precursor solution existing inside the hollow 14 will not readily splashed away. This provides the first conductive film 26 with a film thickness that is greater at inside the hollow 14 than the other portion, as shown in Figure 2(B).

Then, a film 28 for providing a ferroelectric 18 is formed over a surface of the first conductive film 26 by the sol-gel technique, as shown in Figure 2(C). That is, a PZT (lead zirconate titanate) precursor solution is applied onto the surface of the first conductive film 26 by spin coating. The applied film is cured into a gel dry film. After forming the film 28, this structure overall is subjected to a heat process with utilizing RTA (Rapid Thermal Annealing) apparatus. The organic substances contained in the first conductive film 26 and film 28 are thermally decomposed and removed out of these films. Then, a

second conductive film 30 is formed of platinum (Pt) over the film 28 by sputtering, as shown in Fig. 2(D).

Then, the second conductive film 30, the film 28 and the first conductive film 26 are sequentially etched (RIE technique) and removed of unwanted portions, as shown in Fig 2(E). The etch process requires to etch a total film thickness of the second conductive film and the film 28, i.e. by an amount for a thickness of an upper electrode 20 and ferroelectric 18. Nevertheless, it is satisfactory for the first conductive film 26 to be etched only at areas extending out of the hollow 14. As described before, the portion extending out of the hollow 14 is smaller in thickness than a lower electrode 16. For this reason, an etch time is reduced as compared to the prior art requiring to etch the entire thickness of a lower electrode 16.

This structure is heat-processed using an RTA apparatus to bake and crystallize the first conductive film 26 and film 28. This provides a lower electrode 16 of irridium oxide (IrO_2) as well as a ferroelectric 18 of lead zirconate titanate (Pzt). In this embodiment, the second conductive film 30 on the film 28 is formed of platinum (Pt) with preferential orientation. Accordingly, the crystallization in the ferroelectric 18 occurs in an orientation similar to that of the second conductive film 30. That is, the ferroelectric 18 can be controlled in orientation depending upon the second conductive film 30. After forming a lower electrode 16, ferroelectric 18 and upper electrode 20 in this manner, a second insulation film 22 is formed of silicate glass containing phosphorus (PSG) or silicate glass containing boron/phosphorus covering these elements by CVD, as shown in Figure 1.

According to the present embodiment, a hollow 14 was formed in the top surface of the insulation film 12 so that a lower electrode 16 can be formed inside the hollow 14 by the sol-gel technique including a spin-coating application process. As stated before, it

is therefore possible to decrease an etch time to provide a lower electrode 16. This in turn reduces the time for which the film 28 for providing a ferroelectric 18 is exposed to a dry-etching plasma atmosphere. Thus, the ferroelectric 18 can be prevented from being deteriorated in characteristics by the affection of a plasma.

5 A ferroelectric memory 32 of another embodiment, shown in Figure 3, has a hole 34 formed through a second insulation film 22 covering a lower electrode 16, a ferroelectric 18 and an upper electrode 20. The hole is buried with an upper electrode 20.

10 To fabricate a ferroelectric memory 32, spin coating is conducted to form a first conductive film 26 and film 28 over a first insulation film 12 formed with a hollow 14, as shown in Figure 4(A). Subsequently, as shown in Figure 4(B) etching is made (by an RIE technique) on the film 28 and first conductive film 26 to remove unwanted portions. The resulting structure is subjected to a heating process using an RTA apparatus. Then, a second insulation film 22 is formed in a manner covering the first conductive film 26 and film 28, as shown in Figure 4(C). The film 22 at its top surface is planarized by
15 implementing a CMP (Chemical-Mechanical Polishing) technique. Thereafter, as shown in Figure 4(D) etching is made (by RIE) on the second insulation film 22 to open a hole 34. Then, a second conductive film 30 is formed over the second insulation film 22 in a manner filling this hole 34 by a spin coating technique (sol-gel technique). The second conductive film 30 and second insulation film 22 are planarized at top surfaces by the
20 CMP (Chemical-Mechanical Polishing) technique. Thereafter, the resulting structure is subjected to heating process using an RTA apparatus to bake and crystallize the lower electrode 16, ferroelectric 18 and upper electrode 20. The planarization process may use etching in place of the CMP technique. In the case of etching, the upper electrode 20 at its top surface is somewhat higher than a top surface of the second insulation film 22, as
25 shown in Figure 5.

In also this embodiment, it is possible to shorten a time that the film 28 is exposed to a plasma atmosphere during conducting a dry etch process, similarly to the former embodiment. Accordingly, the ferroelectric 18 can be prevented from being deteriorated in characteristic. Meanwhile, the upper electrode 20 is buried in the hole 34, and further planarization is made for the top surfaces of the upper electrode 20 and second insulation film 22. It is therefore possible to form, on the second insulation film 22, an interconnect film in connection with the upper electrode 20.

Incidentally, in the above embodiments, the first conductive film 26 portion extending out of the hollow 14 was removed by etching in the process of Figure 2(E) or Figure 4(B). Alternatively, this portion may be utilized for an interconnection 32 without being etched, as shown in Figure 6(A) or Figure 6(B).

Also, in the process of Figure 2(C) or Figure 4(A), the film 28 was formed without planarizing the top surfaces of the first conductive film 26 and first insulation film 12. Alternatively, the film 28 may be formed after planarizing these top surfaces by a CMP (Chemical Mechanical Polishing) technique or etching. In such a case, an etch time can be further shortened because of no necessity of etching the first conductive film 26 portion extending out of the hollow 14 in the later process. Also, in order to eliminate surface roughening in the first conductive film 26 due to a planarization process, a thin film 36 may be formed on a surface of the planarized first conductive film 26 by using a same material as that of the first conductive film 26 as shown in Figure 8.

Also, a film 38 with a thickness of approximately 1000 angstroms may be formed of silicon nitride (SiN), silicon nitride oxide (SiON) or the like in a predetermined depth position of the first insulation film 12 so that this film 38 can be utilized as an etch stop for forming a hollow 14. The provision of a film 38 makes it possible to planarize a bottom surface of the hollow 14 at a predetermined depth. Accordingly, a lower electrode 16

(Figure 1, Figure 3) can be stably formed on the bottom surface. This structure also serves to block the water content contained in the insulation film 12 below the film 38 from reaching the ferroelectric 18 thorough the lower electrode 16. It is therefore possible to prevent the ferroelectric 18 (Figure 1, Figure 3) from being deteriorated in characteristic by the water content effect.

Meanwhile, as shown in Figure 10, a first electrode portion 16a may be formed at a corner of the hollow 14 by a process including spin coating (e.g. sol-gel technique)so that a second electrode portion 16b can be formed to provide a lower electrode 16. In this case, if the second electrode portion 16b is formed by a process including a spin coat technique (e.g. sol-gel technique), it is possible to decreases an amount of depression to be caused in a top surface center thereof upon baking the lower electrode 16. Meanwhile, if the second electrode portion 16b, or first conductive film 26b, is formed by sputtering, the variation in crystalline orientation is reduced in a top surface of the lower electrode 16, as shown in Figure 11. This serves to stabilize a crystalline state of the ferroelectric 18 (Figure 10) to be formed on the lower electrode 16. Furthermore, if the first electrode portion 16a is formed over the entire bottom surface of the hollow 14 as shown in Figure 12, the second electrode portion 16b can be made thin in thickness by a corresponding amount to the film thickness of the first electrode portion 16a. This reduce the amount of etching to be conducted in the etching process.

Meanwhile, the lower electrode 16 may use ruthenium oxide (RuO_2), rhodium oxide (RhO_2) or palladium oxide (PdO_2) in place of irridium oxide (IrO_2). In such a case, a precursor solution is formed containing an ingredient element of ruthenium (Ru), rhodium (Rh), palladium (Pd) or the like.

Although in the above embodiments the lower electrode 16 and upper electrode 20 (Figure 3, Figure 5) were formed by the sol-gel technique, they may be formed by another

process including spin coat process, such as in an MOD method (organic-metal decomposition).

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of the present invention being limited
5 only by the terms of the appended claims.

WHAT IS CLAIMED IS:

1. A ferroelectric memory, comprising:
 - an insulation film;
 - a hollow formed in a top surface of said insulation film;
 - 5 a lower electrode formed in said hollow;
 - a ferroelectric formed on said lower electrode; and
 - an upper electrode formed on said ferroelectric.
2. A ferroelectric memory according to claim 1, further comprising a film formed in a bottom of said hollow and separating between said insulation film and said lower electrode.
10
3. A ferroelectric memory according to claim 1 or 2, wherein said lower electrode includes a first electrode portion formed at a corner of said hollow and a second electrode portion formed on said first electrode portion.
4. A ferroelectric memory according to any of claims 1 to 3, wherein said lower electrode is formed on a surface thereof with thin film of a same material as that of said lower electrode.
15
5. A ferroelectric memory according to any of claims 1 to 4, wherein said lower electrode and said insulation film at respective top surfaces are planarized flush with each other.
- 20 6. A method for manufacturing a ferroelectric memory, comprising:
 - (a) forming an insulation film on a semiconductor substrate;
 - (b) forming a hollow in a surface of said insulation film;
 - (c) applying a lower electrode in said hole;
 - (d) forming a ferroelectric film on said insulation film; and
 - 25 (e) forming an upper electrode on said ferroelectric film.

7. A manufacturing method according to claim 6, wherein said step (c) is to form said lower electrode by sol-gel method.

8. A manufacturing method according to claim 6 or 7, wherein said step (c) includes the following steps of (c1) forming conductive film on a top surface of said insulation film including an inside of said hollow by a spin coating method, and (c2) removing by etching said conductive film at a portion other than said hollow.

9. A manufacturing method according to claim 6 or 7, wherein said step (c) includes steps of (c3) forming a first electrode portion at a corner of said hollow by a process including a spin coating method, and (c4) forming a second electrode portion in said first electrode portion.

10. A manufacturing method according to claim 9, wherein said step (c4) is to form said second electrode portion by a process including a spin coating method.

11. A manufacturing method according to claim 9, wherein said step (c4) is to form said second electrode portion by sputtering.

12. A manufacturing method according to any of claims 6 to 11, wherein said step (b) includes steps of (b1) forming a film in said insulation film at a predetermined depth position from a top surface thereof, and (b2) forming said hollow by etching said insulation film utilizing film as an etch stop.

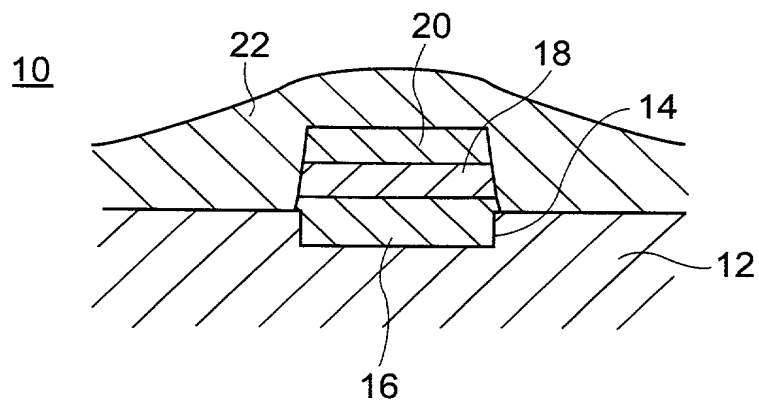
13. A manufacturing method according to any of claims 6 to 12, further comprising step of (f) planarizing a top surface of said lower electrode, wherein a ferroelectric is formed thereon.

14. A manufacturing method according to any of claims 6 to 12, further comprising steps of (f) planarizing a top surface of said lower electrode, and (g) forming a thin film thereon of a same material as said lower electrode, wherein said ferroelectric is formed thereon.

ABSTRACT OF THE DISCLOSURE

Ferroelectric memory includes a hollow formed in a first insulation film. A lower electrode is formed in this hollow by sol-gel method including an application process due to a spin coat method. In this application process, a precursor solution is dripped on a surface of the first insulation film and splashed away due to centrifugal force. Due to this, a first conductive film to being formed has an increased film thickness at portion of the hollow where the precursor solution is ready to correct, or portion to be formed into a lower electrode, and a decreased film thickness at portion other than the hollow. Accordingly, it is satisfactory to etch only the hollow portion when forming a lower electrode by dry-etching the first conductive film.

FIG. 1



D
C
B
A

FIG. 2

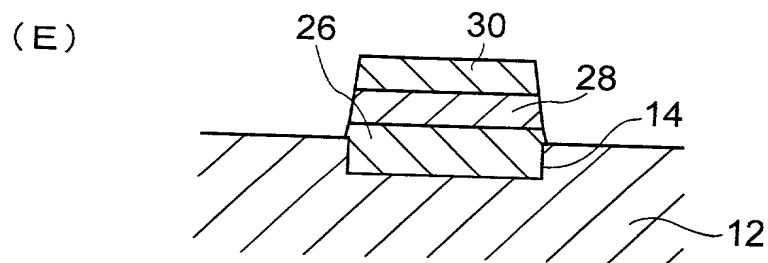
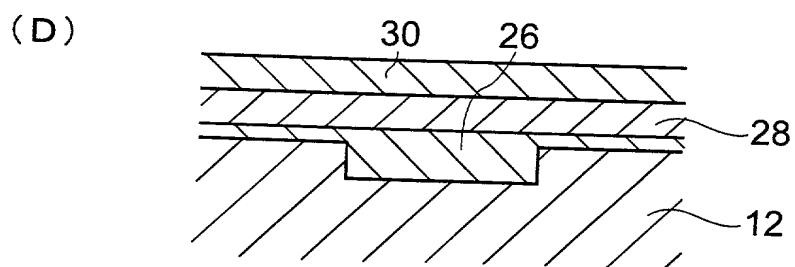
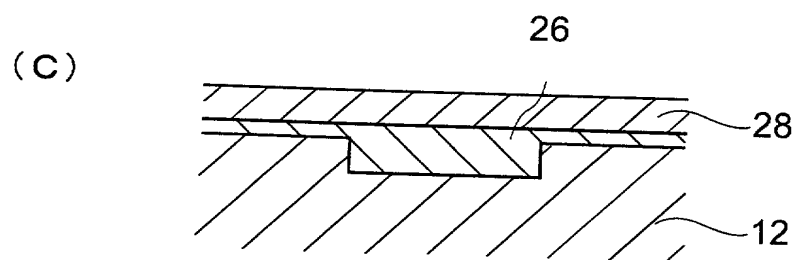
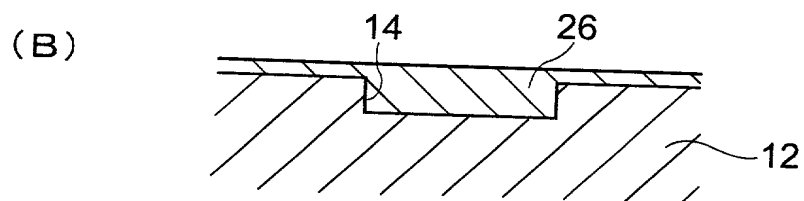
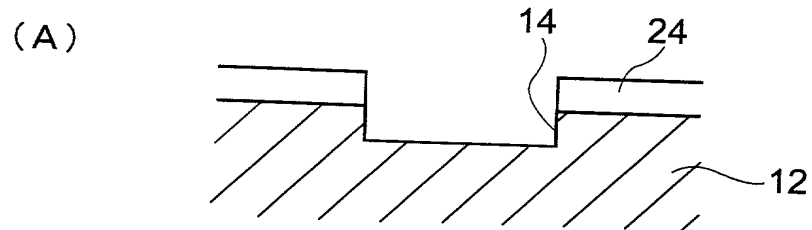


FIG. 3

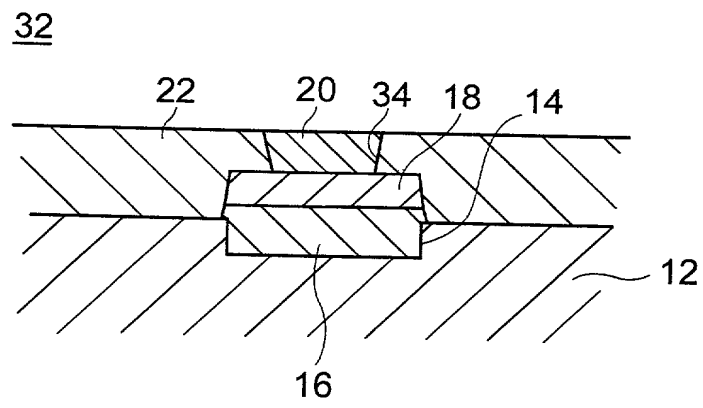


FIG. 4

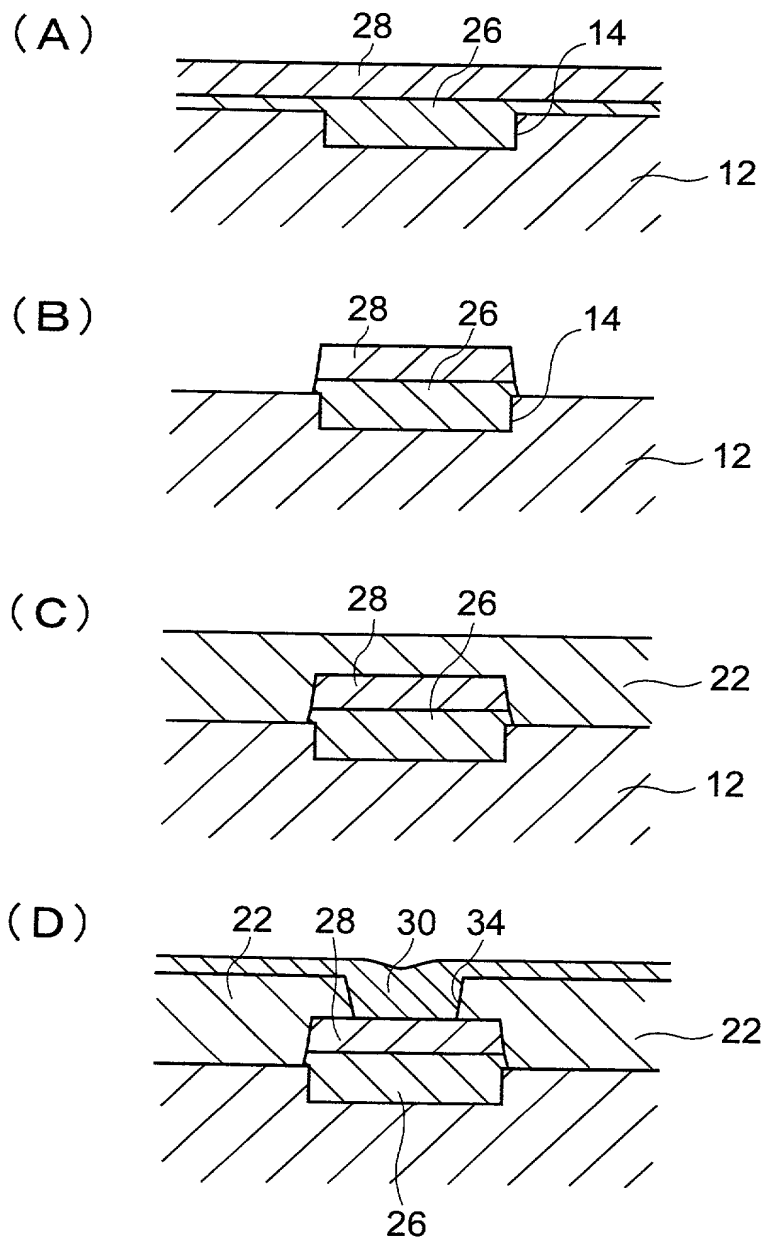


FIG. 5

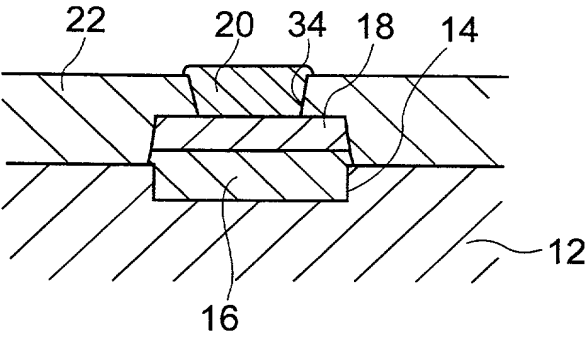
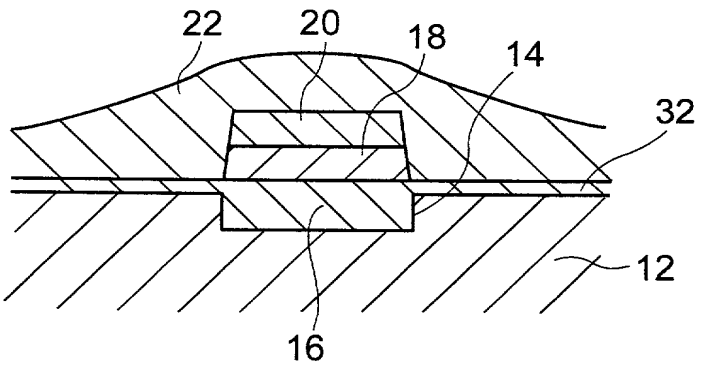


FIG. 6

(A)



(B)

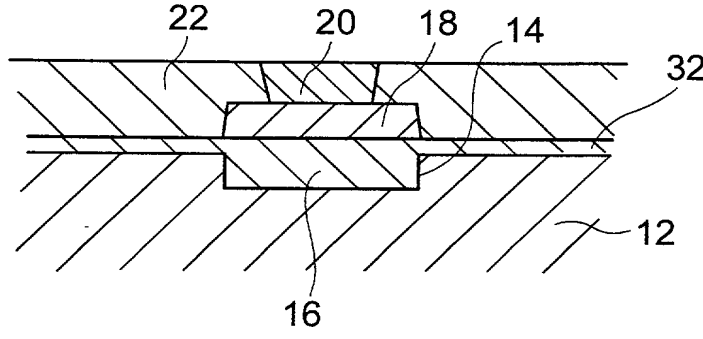


FIG. 7

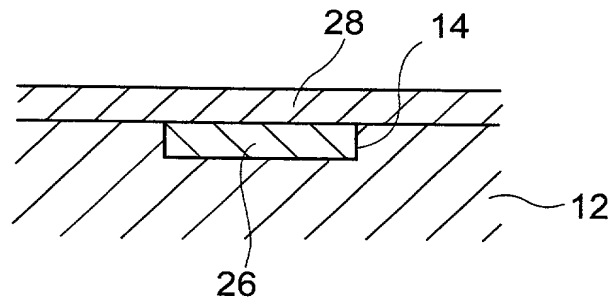


FIG. 8

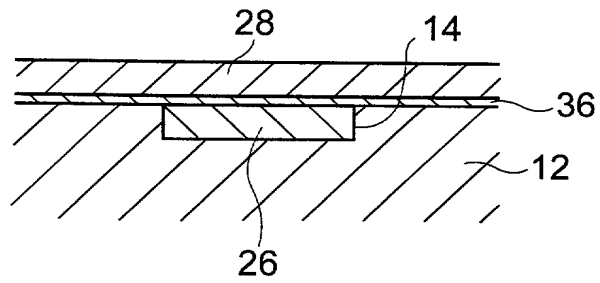


FIG. 9

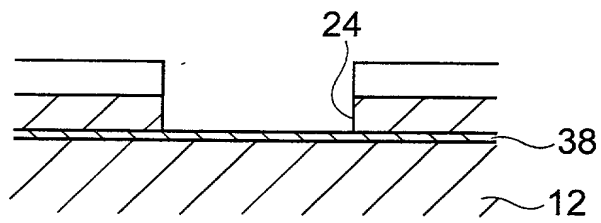


FIG. 10

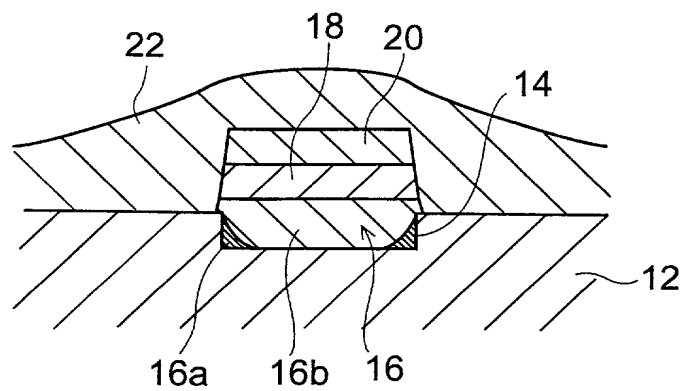


FIG. 11

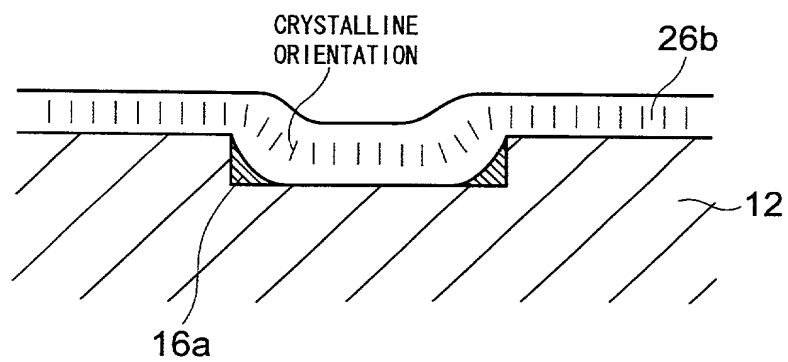


FIG. 12

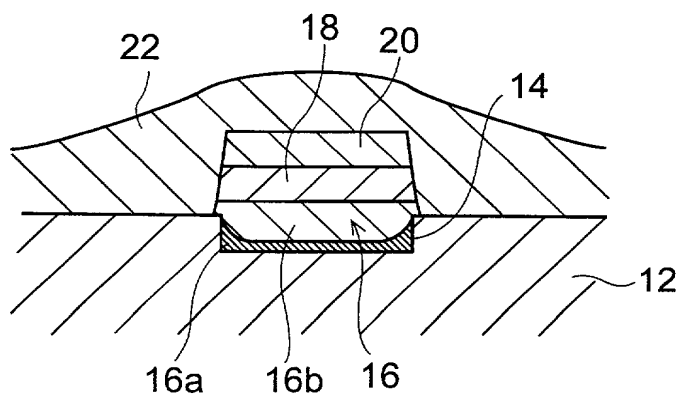


FIG. 13

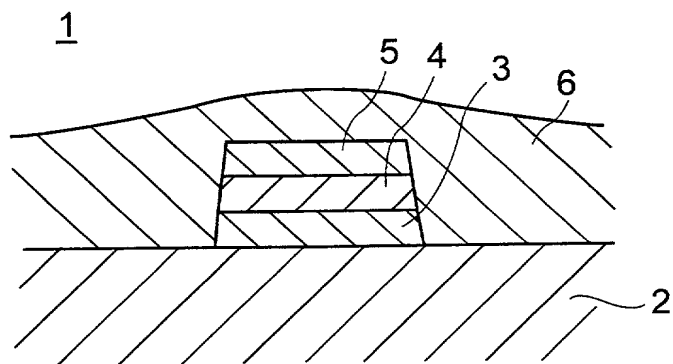
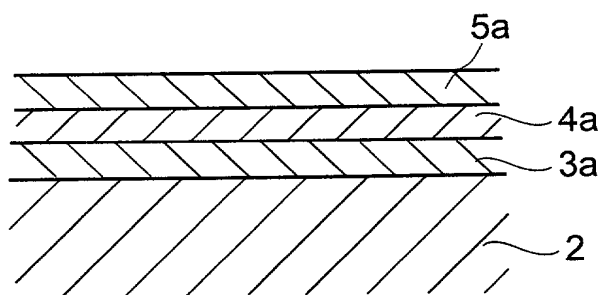


FIG. 14

(A)



(B)

